

## Studying the rate of heat stress in bakers

Javad Malakouti<sup>a</sup>, Ahmad Reza Yari<sup>b</sup>, Navid Safavi<sup>c</sup>, Gharib Majidi<sup>d</sup>, Shahram Nazari<sup>d\*</sup>,  
Soudabeh Alizadeh Matboo<sup>e</sup>, Shahram Arsangh Jang<sup>f</sup>, Mohammad Soleimanpour Nouran<sup>e</sup>

a Instructor, Department of occupational health engineering, School of public health, Qom University of medical science, Qom, Iran.

b Research center for environmental pollutants, Qom university of medical sciences, Qom, Iran.

c School of Public Health, Tabriz University of Medical Sciences, Tabriz, Iran.

d School of Public Health, Qom University of Medical Sciences, Qom, Iran.

e School of Public Health, Ardabil University of Medical Sciences, Ardabil, Iran.

f Instructor, Department of public health, School of public health, Qom University of medical science, Qom, Iran.

\*Correspondence should be addressed to Mr. Shahram Nazari; Email: Shahramnazari73@yahoo.com

### A-R-T-I-C-L-E I-N-F-O

#### Article Notes:

Received: July 2, 2014

Received in revised form:  
Dec 18, 2014

Accepted: Dec 26, 2014

Available Online: May 13,  
2015

#### Keywords:

Heat Stress

WBGT

Bakers

### A-B-S-T-R-A-C-T

**Background & Aims of the Study:** Nowadays heat stress is one of the most current harmful physical agents in workplaces. Attentions to recognized consequences of heat stress and have no information about heat stress in Ardabil bakeries, this study have been done in 2013.

**Materials & Methods:** This cross sectional research has been done in 96 different bread types bakeries in Ardabil. Among 301 bakeries in Ardabil city, 96 of them have been selected by stratified random sampling method. These 96 bakeries include 32 Barbaric bakeries, 45 Lavash, 15 Sangak and 4 special bakeries. To determine heat stress, WBGT index and WBGT meter made of Casella Company have been used.

**Results:** Mean of total WBGT index in oven workstation and kneader workstation showed this index in traditional Barbaric, Lavash, Sangak, respectively was more than special bakeries. Special bakeries have least heat stress among other bakeries. This study showed 80.2% of workers in oven workstation and kneader workstation had heat stress.

**Conclusions:** According to results of this study can state indoor WBGT index in special bakeries with least level of heat stress is better than other bakeries and traditional Barbaric identified as most unsuitable place. Workers in traditional bakeries exposed to heat stress.

**Please cite this article as:** Malakouti J, Yari AR, Safavi N, Majidi Gh, Nazari Sh, Alizadeh Matboo S, Arsangh Jang Sh, Studying the rate of heat stress in bakers. Arch Hyg Sci 2015; 4(1): 7-12.

## Background

Working in heat areas leads to stress in workers, and can cause various diseases besides reducing working ability (1). Ability of activity and working in high temperature area directly depends on the amount of heat stress (2). The most important complications of working in warm areas are heat exhaustion, heat cramp, body dehydration, heat rash, sweat reduction and heatstroke (3). Also, heat has been known to be a risk factor in cardiovascular diseases and can be influential in events as a result of

working (1). The WBGT index was introduced by Yaglou and Minard in 1957, with the aim of studying environmental heat conditions and possibility of its dangers during the navy drills in desert occupations of American Army (3,4,5). This index is used widely (6), and application of WBGT index is recommended in various studies (6,7,8,9,10,11). This index has been selected by the American state community of experts in industrial health, as an index to study the workers' encounters in working areas (9). The national society of job security and safety, and the international standard organization (ISO) have also recommended this

index to be used in evaluating the heat conditions (14, 13).

So far, many studies have been conducted nationwide in connection with determining the heat stress in bakeries. In the study conducted by Golmohammadi and *etal* in 2006 about comparing heat stress indexes (HIS) and WBGT in Hamadan machine bakeries, it was recognized that distribution of HIS index has various weaknesses than index WBGT. It was also found in this study that distribution of HSI index has various weaknesses than index WBGT (7).

Mohammad Ali Ghajar Koohestani (2004) conducted a study about heat stress indexes on workers of Sari bakeries. The results obtained from this study, the machine packed bread bakeries, with the least WBGT amount, was introduced as the most suitable place for providing bread, and the oven machine bread bakery, was introduced as improper place for providing bread (15).

Mitra Hanani (2003) conducted a study with the aim of studying areas' heat stress on workers of Kashan bakeries, using WBGT system. The study was done on 175 subjects of bakeries, and determined that 107 of all workers (61.1 percent) worked at heat stress areas. Also, the workers worked at bakeries equipped with cooking technology, were 3.3 times more than workers in machine bakeries faced with heat stress (1).

**Aims of the study:** Considering the heat effects on workers in warm areas and lack of awareness from heat stress situation in Ardabil bakeries, this study was done with the aim of surveying workers facing with heat factors in Ardebil bakeries.

## Materials & Methods

The present study is of descriptive analytic one, done on summer 2012, in Ardabil city. According to the surveys during study, it was clear that 301 bakeries are active in Ardabil

city. Considering the formula determining the sample capacity, 96 bakeries were calculated as samples in this study;

Considering the kind of bread produced and baking system, 96 of 301 bakeries were selected by random sampling classification. The selected 96 units consists of 32 flat bread bakeries, 45 thin bread bakeries, 15 stone bread bakeries, and 4 especial bread bakeries.

$$n_o = \frac{z^2 p(1-p)}{d^2} = \frac{(1.96)^2 \times (0.9)(0.1)}{(0.05)^2} = 138.29 \approx 139$$

$$n = \frac{n_o}{1 + \frac{n_o}{N}} = \frac{139}{1 + \frac{139}{301}} = 95.08 \approx 96$$

The measurements were done on August and at 11 to 13 o'clock. In each baker, regardless of baking type, two places, one in front of furnace, and the other in front of kneader, totally 192 stations were selected for the evaluation. Following the preliminary surveys in Pilot's, it was found that these two were the most encountering places during the working days of bakeries. The calibrated WBGT meter, made in Casella Company was used in this study to measure the index parameters WBGT, which was in accordance with NIOSH Standard and equipped with certain tools determining the natural moist, dry, and the sun temperatures (15). The WBGT meter was first adjusted on a tripod in each station, and the determined parameters were measured in 3 elevations, ankle (0.1 meter), waist (1.1), and head (1.7 meter). After each evaluation of data, and digits obtained based on the kind of clothing, the adaptability and working type of workers were recorded, and at the end, the WBGT was calculated in accordance with relation No.1 and the WBGT average according to the relation 2:

$$\text{WBGT indoor} = 0.7\text{tnw} + 0.3\text{tg} : (1)$$

$$WBGT_T = \frac{(WBGT \text{ at head} + 2WBGT \text{ at trunk} + WBGT \text{ at foot})}{4} : (2)$$

Considering that all under study subjects (individuals with more than a week working in determined the area) were part of adjusted group and in view of energy consumption, related to the average level. The amounts obtained, accorded with the recommendation of ISO organization in standard number 7243 (Table.1) compared with standard amount 28 degrees centigrade (14). Excel 2007 and SPSS 16 software were used to data analyzes. The independent T Tests were used to analyze and compare the difference between the WBGT average with standard amount 28 centigrade, and for comparing the average heat stress among workers in front of furnace with kneader in each bakery. The Chi-square test and certain method used to compare the heat stress ratio among individuals with respect to the kind of bakery and working place, and also, the method of analysis and one-sided variance and LSD Test were used to compare the total WBGT average between bakeries.

## Results

The results of studying the WBGT index in 32 traditional flat bread (Barbaric) bakeries (including 64 stations), 45 machine thin bread bakeries (Lavash) (including 90 stations), 15 traditional stone (Sangak) bread (including 30 stations), and 4 especial bakeries (including 8 stations) were given in table2. The amount of WBGT in front of furnace and in head height (1.7meter) in traditional flat bread bakeries, assigned the highest amount for itself among bakeries and other areas.

The results obtained from study shows that the bakers in traditional flat bread and especial bread bakeries (in front of furnace) assigned the most and the least amount of WBGT, with the average temperature 33.68 and 27.96 degrees centigrade respectively for themselves. And the worker of traditional flat bread bakery (in front

of kneader) with the average temperature 30.68 and 26 degrees centigrade have the most and the least amount of total WBGT, respectively.

The average of Total WBGT index in front of furnace and kneader in bakeries show that these indexes in traditional flat bread, thin bread, and stone bread bakeries, is more than especial bread bakeries. In diagram.1, the Total WBGT index average measured based on type of bakery and station.

It was found by comparing the collected data with standard amount 28 degrees centigrade that 80.2% of workers in furnace and kneader are in danger of heat stress. The findings are given in table.3.

The results of variance analysis represents the statistical difference among the WBGT average of flat bread bakeries, thin bread and stone bread in front of furnace, also the flat bread and thin bread bakeries in front of kneaders, with 28 degrees centigrade standard amount ( $p < 0.0001$ ). The difference between WBGT average of stone bread bakeries in front of kneader with standard amount, was not significant ( $p > 0.05$ ).

The results of independent T test showed significant difference between the average heat stress opposite furnace with kneader in bakeries of flat bread, thin bread and stone bread. ( $p < 0.0001$ ).

The results of one-sided variance analysis test and the differences among groups showed significant difference between the average heat stress “flat bread bakeries with stone bread and especial bread bakeries”, and also “thin bread bakeries with stone bread and especial bread bakeries” in front of kneader ( $p < 0.001$ ). But statistically there was no significant difference between the WBGT average of flat bread bakeries with thin bread and also the stone bread with especial bread bakeries in front of kneader ( $p > 0.05$ ). Also, there was statistically

significant difference between WBGT average in front of furnace of all bakeries ( $p < 0.01$ ). Considering the results Tukey HSD, in view of harmony, the WBGT average obtained for kneader front, two subsets including stone bread with especial bread and flat bread with thin bread, and three subsets including bakeries of flat bread, thin bread and stone bread bakeries with especial bread, were considered. Due to the little capacity of sample inside the floors, exact tests were used to study the relationship between kneader front heat stress and type of bakery. Statistically significant relation was seen between heat stress and type of bakery in a 5 Percent level. Based on the descriptive and analytic results, it can be stated that by changing flat bread bakery into think bread one, the heat stress of stone bread and especial bread degrades gradually from those

individuals working in front of kneader. The results show in fig. 1.

## Discussion

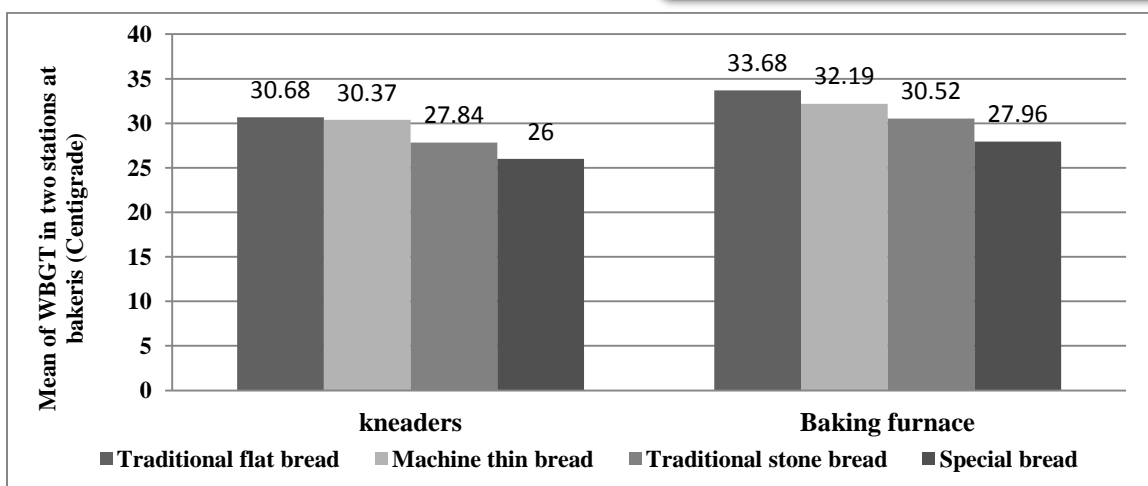
The study was conducted with the aim of surveying bakers' encountering rate with heat factor in bakeries of Ardebil city. Regardless of baking technology, the heat stress among bakery workers is different in proportion with location of working station and distance from heat source (baking furnace). Comparing the average amount of WBGT index with recommended standard amount (28 degrees centigrade) indicate the heat stress existence among workers in front of traditional flat bread bakeries', thin bread and stone bread furnace that the issue is in accordance with the results of Golmohammadi and *et al.*; studies conducted among workers in Hamadan bakeries (7,16).

**Table 1: WBGT reference values from ISO 7243**

Metabolic rate M ( $Wm^{-2}$ )	Reference value of WBGT			
	Person acclimatized to heat ( $^{\circ}C$ )		Person not acclimatized to heat ( $^{\circ}C$ )	
	No sensible air movement	Sensible air movement	No sensible air movement	Sensible air movement
0. Resting $M \leq 65$				
1. $65 < M \leq 130$	33		32	
	30		29	
2. $130 < M \leq 200$	28		26	
3. $200 < M < 260$				
	25	26	22	23
4. $M > 260$	23	25	18	20

**Table 2: Mean of WBGT at bakeries (Centigrade)**

At kneaders			At baking furnace			Measuring station	
Foot	Trunk	Head	Foot	Trunk	Head	Level	
28.73	30.66	32.66	32.11	33.69	35.24	Mean of WBGT	Traditional flat bread
1.32	1.92	1.69	1.35	1.55	1.4	Std of WBGT	
28.26	30.67	31.89	30.09	32.64	33.38	Mean of WBGT	Machine thin bread
4.36	2.55	2.14	1.46	1.75	1.67	Std of WBGT	
25.82	28.05	29.44	29.2	30.6	31.68	Mean of WBGT	Traditional stone bread
0.65	1.02	0.99	1.18	1.35	1.13	Std of WBGT	
25.17	26.62	25.57	26.58	28.8	27.65	Mean of WBGT	Special bread
0.78	0.72	0.59	0.37	1.26	1.24	Std of WBGT	



**Fig1: Mean of total WBGT in bakeries**

Almost all laborers working in front of bakery furnace of traditional flat bread, thin bread and stone bread face with heat stress; since the source of heat stress in bakeries, is baking furnace, it is not far reaching issue. All laborers in bakeries of traditional flat bread and in bakeries of thin bread, 62% of laborers working in front of kneader, face with heat stress, which is considerable frequency. The wide range of heat exchange in furnace of these two bakeries causes more heat to be transferred into the bakery space, and the heat is transferred into other parts in case the cooler system is not suitable, and the insulation of furnace walls is improper, and workers in those areas are too affected by heat stress. In all under study trade units, the average amount of heat stress in front of kneader determined lower than the front of furnace. This difference was significant in flat bread, thin bread and stone bread bakeries ( $p < 0.0001$ ); the distance between kneaders and baking furnace can be the reason for this issue. The total WBGT average, in two places, front of furnace and kneader in bakeries showed that this index in bakeries of traditional flat bread, thin bread and stone bread is more than bakeries of especial bread. The issue mostly is due to the difference in natural wet, and sun temperatures measured in each bakery, which

was different considering the baking technology.

The bakeries of flat bread and thin bread in front of kneader has statistically significant different with bakery of stone bread and especial bread. The distance between the kneader and providing paste in front of furnace in stone bread and especial bread bakeries can be the reason for this issue.

Also, statistically significant difference was seen between WBGT average of furnace in all bakeries ( $p < 0.01$ ). This issue is because of difference in bread baking style and difference in under study parameters. For example, due to the open flame in units of traditional flat bread bakery, the rate of radiant temperature was determined more than other bakeries.

Considering that the number of especial bread bakeries in Ardebil city, was lower than traditional bakeries, hence, fair judgment about these bakeries is ponderous in this study. It is recommended to pay much attention to this issue in the next studies.

## Conclusion

The especial bread bakeries, with the least amount of WBGT in the work station, are the most suitable ones in view of heat conditions, while flat bread bakeries are unsuitable ones.



Working at traditional bakeries has higher heat stress on workers. Correcting methods and baking technology can have great contribution in reducing the amount of heat stress among workers of trade units.

## Footnotes

### Acknowledgments:

At the end, the researchers appreciate the trade unions of Ardabil bakeries, faculty of health, Ardebil University of medicine, laborers of bakeries and people who assisted and played role in doing this study.

### Funding/Support:

This study has financially supported by Ardabil University of Medical Sciences.

### Conflict of Interest:

The authors declare no conflict of interest.

## References

1. Hanani M, Motalebi Kashani M, Mosavi SGA, Bahrami A. Survey of environmental heat stress in Kashan bakery workers. *Fiez* 2004;8(3):25-29[Full Text in Persian].
2. Moran DS, Epstein Y. Evaluation of the Environmental Stress Index (ESI) for Hot/Dry and Hot/Wet Climates. *Industrial Health* 2006;44(3):399-403.
3. Golbabaee F, Tirgar A, Alimohamadi I. Occupational health in hot environment. 1th ed. Tehran:university of Tehran press 2004;57-72[Full Text in Persian].
4. Golbabaee F Omidvari M. Man & thermal environment: 1th ed. Tehran:university of Tehran press 2002;216-222 [Full Text in Persian].
5. Moran DS, Pandolf KB, Shapiro Y, Heled Y, Shani Y, Mathew WT, et al. An environmental stress index (ESI) as a substitute for the wet bulb globe temperature (WBGT). *Thermal Biology* 2001;26(4-5):427-431.
6. Budd GM. Wet-bulb globe temperature (WBGT)—its history and its limitations. *Science and Medicine in Sport* 2007;11(1):20-32.
7. Golmohamadi R, Hasani M, Zamanparvar A, Oliaee M, Aliabadi M, Maahdavi S. Comparison of HIS & WBGT index in Hamedan Bakeries. *Iran work health* 2006;3(3-4):46-51 [Full Text in Persian].
8. Srivastava A, Kumar R, Joseph E, Kumar A. Heat Exposure Study in the Workplace in a Glass Manufacturing Unit in India. *Occupational Hygiene* 2000;44(6):449-453.
9. Moran Daniel S, Kent B, Pandolf Y, Shapiro Y, Heled Y, Shani WT, et al. An environmental stress index (ESI) as a substitute for the wet bulb globe temperature (WBGT). *Thermal biology* 2001;26(4):427-431.
10. Malchaire JBM. Occupational heat stress assessment by the predicted heat strain model. *Industrial Health* 2006;44(3):380-387.
11. d'Ambrosio FR, Palella BI, Riccio G, Alfano G. Criteria for assessing severely hot environments: from the WBGT index the PHS (predicted heat strain) model. *Medicina del lavoro* 2004;95(4):255-274.
12. ACGIH. Threshold limit values for chemical substances and physical agents. American Conference of Governmental Industrial Hygienists; 2004;176-185.
13. Standard for occupational exposures to hot environments .publication No 1992.
14. ISO 7243. Hot Environments – Estimation of the heat stress on working man based on WBGT index (Wet Bulb Glob Temperature), ISO. 1989.
15. Ghajar kohestani MA. Survey of WBGT index in Sari Bakeries 1998-1999. 4th Iran conference of occupational health. 2004; [Full Text in Persian].
16. Seraj J, Ghaemkhani M. Relation between thermal environments of bakeries with bakers [MS thesis]. Tehran University of medical science. 1979; [Full Text in Persian].